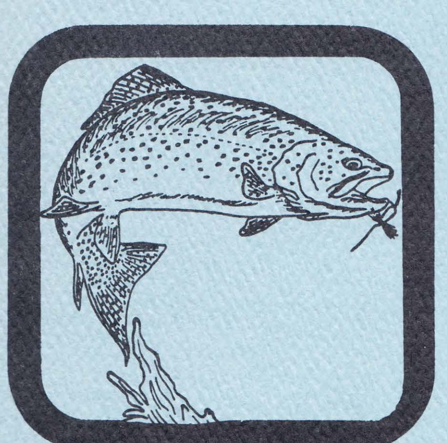
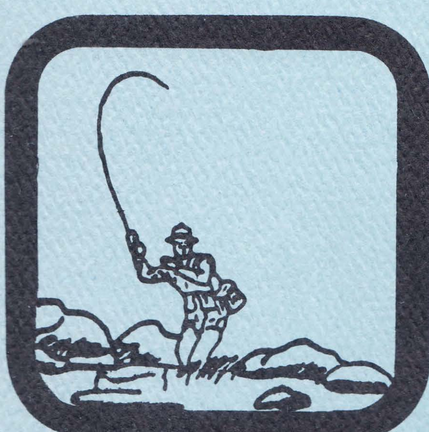
A METHOD FOR PREDICTING FISH RESPONSE TO SEDIMENT YIELDS





U.S.D.A. FOREST SERVICE
INTERMOUNTAIN AND NORTHERN REGIONS
WILDLIFE MANAGEMENT

A METHOD

FOR

PREDICTING FISH RESPONSE

TO

SEDIMENT YIELDS

U.S.D.A. FOREST SERVICE

INTERMOUNTAIN AND NORTHERN REGIONS

WILDLIFE MANAGEMENT

AUGUST 1980

A WORKING DRAFT

AUTHORS

Listed in Alphabetical Order

T. C. Bjornn	Coop. Fishery Unit Leader - University of Idaho
David C. Burns	Forest Biologist - Payette NF
Albert W. Collotzi	Forest Anadromous Fishery Coordinator - Boise NF
Henry W. Newhouse	Forest Biologist - Nezperce NF
William S. Platts	Fishery Research Biologist - Intermountain Station

TABLE OF CONTENTS

APPENDICES

INTRODUCTION

The National Forest Management Act (NFMA) of 1976 requires the completion of Forest Management plans by 1985. The NFMA regulations specify display of alternative management prescriptions and their effect on various resources and values including fish habitat quality. As a result, the Regional Foresters of the Intermountain and Northern Regions directed a group of scientists to develop a method for predicting the effect of sediment on the fishery.

A process is used to evaluate the effect of sediment on the fishery. The process begins with on-site erosion and ends with effects of sediment on fish habitat in a downstream key reach. The effect on fish habitat is then related to effect on fish biomass.

The evaluations given in this document are closely coordinated with methods for predicting sediment yields that have been developed by soil and watershed scientists in the Intermountain and Northern Regions (USDA Forest Service, 1980). The sedimentation methods provide a procedure for obtaining quantified estimates of sediment yields prior to any management and sediment yields in response to given management scenarios including roading, logging, and fire. A model is used to estimate erosion from a given land unit as modified by a management activity. The eroded material is delivered to the stream system, and routed to a key stream reach. The key stream reach refers to a small portion of the stream system where fishery responses to sediment are analyzed.

The information on percent sediment yield over natural that is provided by other specialists is used in the method to evaluate the effects on fishery values.

OBJECTIVE

1. To provide a method for predicting the effect of sediment yield on the fishery[1/].

ASSUMPTIONS

The potential, existing, and natural sediment yield entering a key channel reach can be adequately predicted to evaluate the effects on fishery habitat.

A key stream reach(es) can be identified within each watershed area to display effects on the complete stream.

Increasing sediment yields over natural decreases fish biomass.

Information is available on all Idaho Forests to drive the process.

Other variables besides sediment (e.g., water temperature, oxygen, flow) influence the fishery and will be addressed separately.

1/ The fishery is defined as the fish and their complete habitat.

LIMITATIONS

Curves were developed to relate sediment yields to its effects on the fisheries. They were developed from existing research information (Bjornn (1969), Bjornn et al (1974), Cordone and Kelly (1961), Corley (1979), Hausle and Coble (1976), Klampt (1976), McNeil and Ahnell (1964), Philipps and Cambell (1962), Platts (1970, 1972), Platts and Megahan (1975), Ricker (1975), and Stuehrenberg (1975)), experience, and judgment. The curves represent the best relationships available at this time. The user should be aware that the process does not cover all cases. As an example, the designation of key reaches in high gradient streams such as those draining river-breaks is not covered. River-breaks are typically susceptible to mass failure. Even though routing and deposition may result in no increase in fine sediment under existing levels of disturbance, it would be invalid to draw a conclusion that no fishery impacts occur. The assumption that the impact to downstream areas is less than or equal to the impacts in the sum of individual drainages is false in this case. Lower gradient downstream areas could be severely impacted by cumulative effects.

The relation between sediment yields and fish habitat is only partially understood. In addition, the confounding of sediment yield relationships with other variables such as floods, ice flows, drought, water chemistry, channel morphology, and channel substrate makes it difficult to accurately predict sediment yield consequences.

BACKGROUND USED FOR THE SEDIMENT YIELD/FISHERY ANALYSIS

Fish Population Below Carrying Capacity

With the small, often remanent returns of anadromous fish to Idaho, mortality of embryo and alevins in the spawning gravel could limit populations. Survival of the egg to alevin emergence stage for salmon and steelhead can be established by using the percentage of fines or particle size distribution in the salmonid redd. The survival rates under known conditions have been summarized by Bjornn et al (1974), Hausle and Coble (1976), McCuddin (1977), McNeil and Ahnell (1964), and Shirazi and Seims (1979).

Rearing areas underseeded with salmon and steelhead fry which may result from low spawner abundance, leaves the rearing capacity not fully used and fry, smolt or future adult abundance may be affected. In underseeded areas, embryo survival in redds may regulate smolt or adult abundance and thus fine sediment concentration in spawning areas is of prime importance. This underseeding is taken into account in Figure C-1 (Appendix C). If increased sediment yields result in a higher percentage of fines in spawning gravels, then fry, smolt, and adult yield will be reduced.

Fish Population at Carrying Capacity

When spawning conditions are not limiting the population, but summer and winter rearing areas are; the curve for carrying capacity is used (Figure

C-2). This curve assumes that salmonids usually overseed their rearing area except in anadromous runs in Idaho and possibly overfished stocks of West Slope Cutthroat Trout. The Forest Biologist in cooperation with the Idaho Department of Fish and Game must decide whether the population is at or under the carrying capacity. The following example explains one way this can be done.

> Simulation of the impacts of sediment to salmon stocks can be expressed as changes in the stock-recruitment relationships, Hall and Lantz (1969), Philipps and Cambell (1962), and Platts (1968) (Figure 1). Stock viability can be thought of as the area between any curve and the replacement line. The replacement line designates the points at which each spawner results in one returning adult. Note that this area decreases dramatically from "near natural" conditions (Case No. 1, Table 1) to "highly impacted" conditions (Case No. 3, Table 3). This area is a reflection of the ability of a salmon stock to rebound from other sources of mortality not taken into account on the simulation.
>
> Harvestable surplus also is impacted. The distance between the replacement line and the stock-recruitment curve decreases for a given number of spawning adults. In this simulation 1,000 returning adults produce a harvestable surplus under "near natural" conditions (Case No. 1), but produce none under the circumstances described for the other cases (see Tables 1, 2, and 3). This effect is of considerable economic importance to commercial fishermen.
>
> Potential run size is the final expression of impact which is considered here. Notice that as the conditions become more impacted by sediment, the maximum number of returning adults decreases (Figure 1). Other sources of mortality, such as dams are considered constant in this example.

Juvenile or smolt production when rearing areas are at carrying capacity has been related to the amount of fine sediment in the channel substrate. To determine the impacts in the rearing areas requires defining the relationship between percentage change in sediment yield to embeddedness, geometric mean particle size, particle size distribution, or pool volume. All of these environmental conditions have been related to salmonid juvenile survival by research.

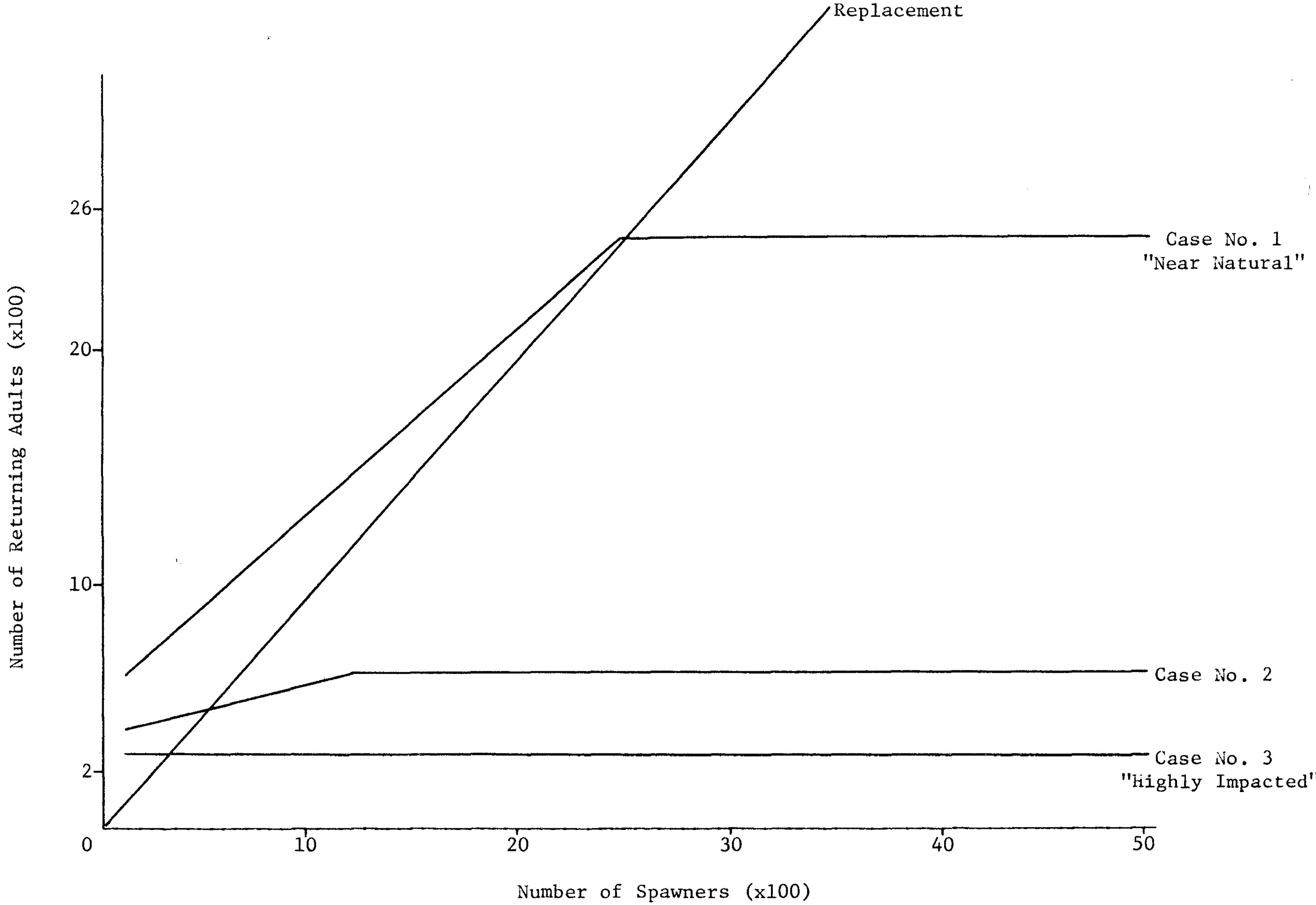


Figure 1. Stock-Recruitment simulation for summer chinook salmon under 3 environmental conditions.

TOTAL NUMBER OF ADULT SPAWNERS	5,000	2,500	1,200	500
NUMBER OF EGGS PRODUCED @ 50/50 SEX RATIO & 4,000 EGGS PER FEMALE	10,000,000	5,000,000	2,400,000	1,000,000
EGG TO EMERGENT SURVIVAL AS A FUNCTION OF % FINES IN SPAWNING AREA (60 PERCENT)	6,000,000	3,000,000	1,440,000	600,000
MAX. CARRYING CAPACITY 3,125,000 JUVENILES MODIFIED BY WINTER SURVIVAL AS EMBEDDEDNESS FN. (80 PERCENT)	2,500,000	2,500,000	2,500,000	2,500,000
NUMBER SMOLTS PRODUCED	2,500,000	2,500,000	1,440,000	600,000
NUMBER OF ADULTS RETURNING FROM CONSTANT 0.1% SURVIVAL	2,500	2,500	1,440	600

Table 1.

Case No. 1

Description: "Near Natural," 20% fines in spawning gravel, 20% embeddedness.

TOTAL NUMBER OF ADULT SPAWNERS	5,000	2,500	1,200	500
NUMBER OF EGGS PRODUCED @ 50/50 SEX RATIO & 4,000 EGGS PER FEMALE	10,000,000	5,000,000	2,400,000	1,000,000
EGG TO EMERGENT SURVIVAL AS A FUNCTION OF % FINES IN SPAWNING AREA (40 PERCENT)	4,000,000	2,000,000	960,000	400,000
MAX. CARRYING CAPACITY 3,125,000 JUVENILES MODIFIED BY WINTER SURVIVAL AS EMBEDDED-NESS FN. (20 PERCENT)	625,000	625,000	625,000	625,000
NUMBER SMOLTS PRODUCED	625,000	625,000	625,000	400,000
NUMBER OF ADULTS RETURNING FROM CONSTANT 0.1% SURVIVAL	625	625	625	400

Table 2.

Case No. 2

Description: "Intermediate," 28% fines in spawning gravel, 50% embeddedness.

TOTAL NUMBER OF ADULT SPAWNERS	5,000	2,500	1,200	500
NUMBER OF EGGS PRODUCED @ 50/50 SEX RATIO & 4,000 EGGS PER FEMALE	10,000,000	5,000,000	2,400,000	1,000,000
EGG TO EMERGENT SURVIVAL AS A FUNCTION OF % FINES IN SPAWNING AREA (28 PERCENT)	2,800,000	1,400,000	672,000	280,000
MAX. CARRYING CAPACITY 3,125,000 JUVENILES MODIFIED BY WINTER SURVIVAL AS EMBEDDED-NESS FN. (10 PERCENT)	312,500	312,500	312,500	312,500
NUMBER SMOLTS PRODUCED	312,500	312,500	312,500	280,000
NUMBER OF ADULTS RETURNING FROM CONSTANT 0.1% SURVIVAL	313	313	313	280

Table 3.

Case No. 3

Description: "Highly Impacted," similar to SFSR, 35% fines in spawning gravel, 60% embeddedness.

Determining Fish Responses to Channel Particle Size Distribution and Embeddedness

Fine sediments entering streams alter particle size distribution and embeddedness, Platts and Megahan (1975). Stream channels in their natural condition are generally at their highest potential for producing fish biomass. Additions of fine sediments to these natural channels decrease fish biomass depending on the amount and degree of the fine sediment deposition.

Changes in embeddedness can be used to determine changes in fish biomass. As the embeddedness rating increases, the fine sediments surrounding the gravel, rubble, and boulder particles also increase. A 100 percent embeddedness rating would refer to a channel that is completely covered with fine sediments, therefore biological productivity would be low. An embeddedness rating of 0 percent would mean all of the surface of each particle (gravel, rubble, boulders) is open to direct water contact and is therefore capable of producing the optimum biomass. Therefore, fish biomass would be at its highest under this condition.

METHODS

Use of Channel Descriptions

Stream channel water handling capabilities depend upon such factors as channel gradient, channel roughness, and sinuosity. Each channel does not transport water or sediments in the same manner. Therefore, stream

channels have been classified into three types, Collotzi (1974) and Newhouse (1979) (Appendix B). The Channel A type was left out of this analysis because it is assumed few key reaches of this type would be selected by biologists. The users need to determine which of these channel types (B or C) best fits the key reach situation.

Determining Loss in Fish Biomass

The Brooks-Cline model (1978) used sediment yield over natural to estimate the effect of sediment on fish biomass. The method presented here adds additional steps in an attempt to obtain a better estimate of sediment effects on fish biomass. Figure 3 is similar to that approach presented in the Brooks-Cline model.

In order to evaluate changes of sediment yield and changes in fish biomass several relationships (Appendix C) must be combined unless the user chooses the direct route provided in Figure 3. The process of evaluating impacts is dependent on the group of relationships selected by the user (Figure 2). The route chosen should be documented. The changes in sediment yields are related to the resulting changes in percent fines in the channel by depth fines (spawning gravels) and surface fines (rearing areas) (see Glossary, Appendix A). Changes in channel embeddedness and changes in pool volume are also related to sediment yield (Appendix C). Once these relationships are chosen, percentage surface fines or depth fines or embeddedness can be related to its effect on incubation or fish biomass (Appendix C).

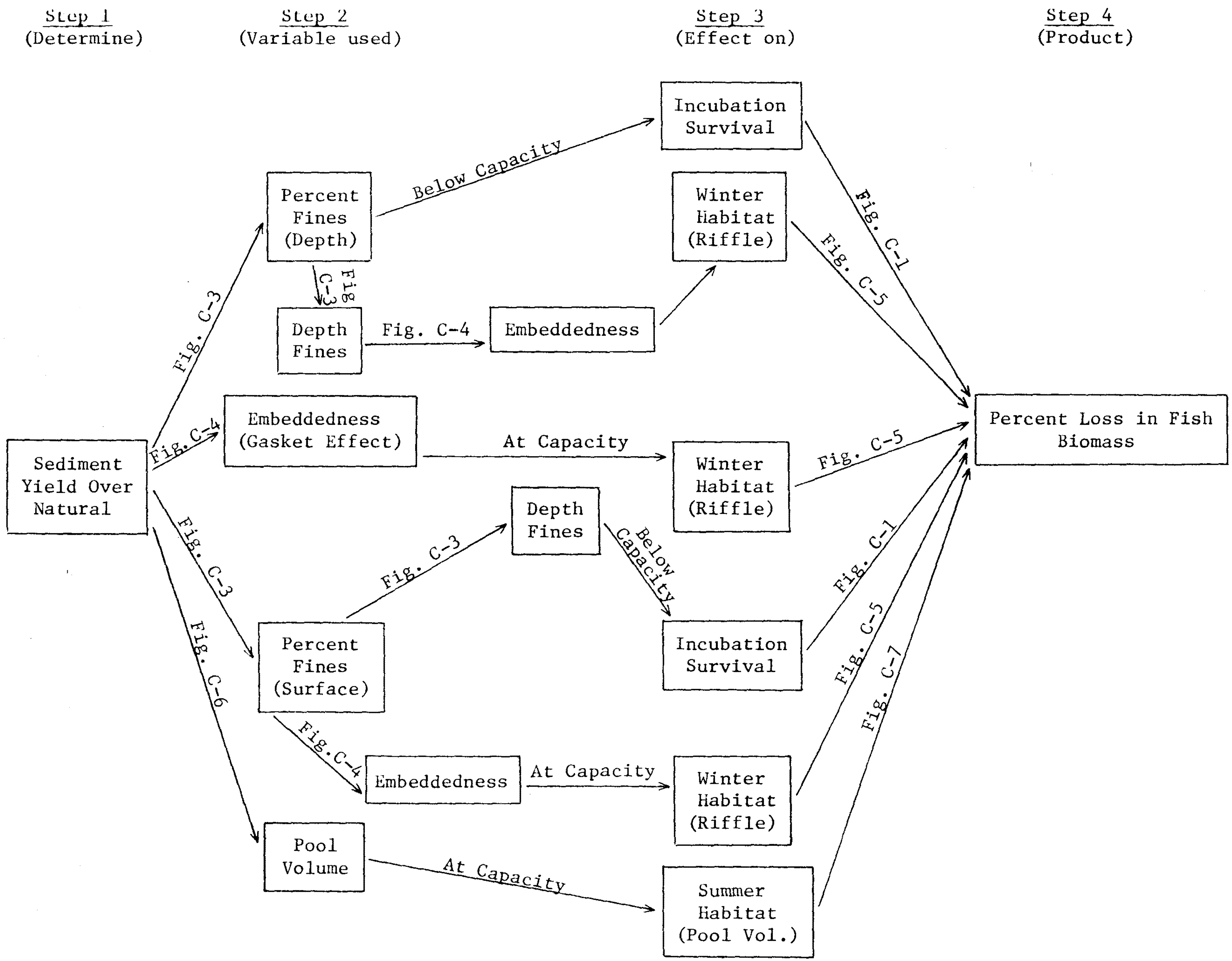


Figure 2. The flow path used to relate sediment yield over natural to loss in fish biomass.

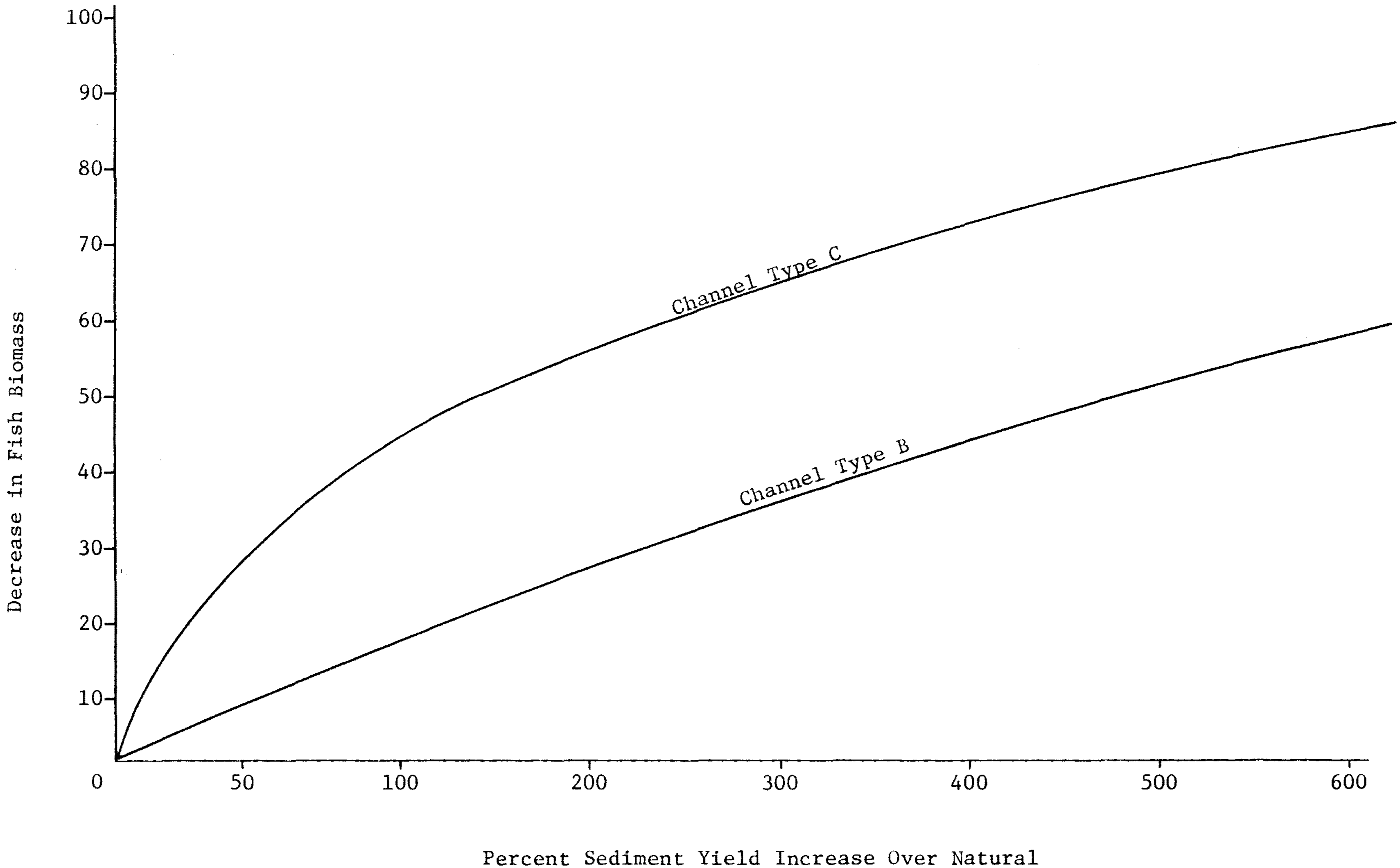


Figure 3.[1/] Sediment Yield over natural compared to fish biomass.

1/ This curve was developed using the average from surface fines, depth fines, embeddedness, and pool volume as developed in Appendix C.

Examples

Example 1

If data on percent Channel fines by depth is available, the following steps could be used.

> If the sediment yield from a proposed land use activity is predicted to be 500 percent[1/] over natural (it is assumed that the rearing habitat is underseeded), then incubation survival would be decreased. If incubation is the limiting factor, then the analysis is routed through the incubation survival steps. The route to take from sediment yield to step 1 (percent depth fines, surface fines, embeddedness or pool volume) depends on the fishery and the data available to the user (Figure 2).

In this example, a 500 percent increase in sediment yield will result in the channel being composed of 32 percent fine sediments by depth (Figure C-3). Emergence success is determined using Figure C-1 as it relates to the amount of fine sediments in the redds. According to the curve, there is only 33 percent survival for anadromous fish which relates to a 67 percent loss in fish biomass (Figure C-2).

1/ Percent increase in sediment yield over natural is figured using the following formula:

$$PSY = \frac{(100)(NSY + ISY)}{NSY} - 100$$

Where:

PSY = Percent sediment over natural
NSY = Natural sediment yield
ISY = Increased sediment yield

Example 2

If the user does not have sufficient data and only sediment yield information is known then the following steps could be used.

> In a C type channel, sediment yield over natural delivered to the key reach is 500 percent. Using Figure 3, the decrease in fish biomass would be 78 percent. The reason for the higher loss in fish biomass in this example over the previous example is that the loss in biomass in Figure 3 is an average of both incubation survival and loss of fish biomass from rearing areas. Example 1 considered only incubation survival.

All Forests have not used identical methodologies in the past to collect data, nor do they have identical data bases. To provide for this, several pathways have been displayed to determine fish biomass consequences so all will arrive at the same end point (Fish Biomass Potential). Each user after documenting their procedure(s) has the option of using the same final curves (Figure 3) to display sediment yield estimates in relationship to fish biomass.

USE IN THE FOREST PLAN

Assumptions used in the development of the method require that the analysis areas be defined so that the chosen key stream reaches are the most sensitive to management activities. This means that the analysis areas must be watersheds or portions of watersheds through which sediment can be routed to an identified key reach. If sediment/fishery continuity between Forests is to be achieved it is critical that the analysis area classifications be similar.

This classification may present problems on individual Forests between disciplines using different analysis area classifications and also between the Forests that use different methods. Adoption of a standard analysis area classification process may require changes in some of the land unit stratification already initiated on some Forests.

Historically, the evaluation of sediment effects on the fishery as an output from linear programs has been a one-step evaluation. The process defined in this report does identify sediment/fish interactions in 1 step, but allows the user to take a multiple-step process that may provide more accuracy. This process identifies sediment impacts as only 1 of the components that can influence a fishery. The user must consider that other conditions that impact fish biomass such as temperature, nutrients, and water flows may be more important and must still be evaluated by the user based on individual concerns. It is possible that any one of these variables may have more influence on the fish population than sediment.

REFERENCES CITED

REFERENCES CITED

Bjornn, T. C. 1969. Embryo Survival and Emergence Studies. Job No. 5, Salmon and Steelhead Harvest. Project F-49-R-7, Annual Completion Department, Idaho Department of Fish and Game. 11 pp.

Bjornn, T. C., M. A. Brusven, M. M. Molnau, F. J. Watts, R. L. Wallace, D. R. Neilson, M. F. Sandine and L. C. Stuchrenberg. 1974. Sediment in Streams and its Effects on Aquatic Life. Resource Tech. Department. OWRT Project No. B-025-IDA, Water Resources Resource Institute, University of Idaho, Moscow. 47 pp.

Brooks, William M., and Richard G. Cline. 1979. Linear Program Evaluation of Management Alternatives Using Literature-Landform Based Sediment Values: A Method. Soil-Air Water Notes 79-1, USDA Forest Service, Northern Region, Missoula MT. 9 pp.

Burns, D. C. 1978. Photographic and Core Sample Analysis of Fine Sediment in the Secesh River. Payette National Forest. USDA Forest Service, McCall, Idaho. 20 pp.

Collotzi, Albert W. 1974. A Systematic Approach to the Stratification of the Valley Bottom and the Relationship to Land Use Planning. Instream Flow Needs Proceedings, Vol. 1, pp. 484-497. American Fishery Service, Bethesda, Maryland.

Cooper, A. C. 1965. The Effects of Transportated Stream Sediments on the Survival of Sockeye and Pink Salmon Eggs and Alevin. International Pacific Salmon Fisheries Commission, New Westminster, B.C. Canada.

Cordone, A. J., and D. W. Kelley. 1961. The Influences of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game. 47(2): pp. 189-228.

Corley, Donald R. 1979. Fishery Habitat Survey of the South Fork Salmon River - 1979. USDA Forest Service, Intermountain Region, Boise National Forest, Boise, Idaho. 90 pp.

Everest, F. H. 1969. Habitat Selection and Spatial Interaction of Juvenile Chinook Salmon and Steelhead Trout in two Idaho Streams. Ph.D. diss., University of Idaho, Moscow. 77 pp.

Graf, W. H. 1971. Hydraulics of Sediment Transportation. McGraw Hill, Inc., New York. 513 pp.

Hausle, D. A., and D. W. Coble. 1976. Influence of Sand in Redds on Survival and Emergence of Brook Trout (Salvelinus fontinalis). Trans. American Fishery Society. 105(1): pp. 57-63.

Klampt, R. R. 1976. The Effects of Coarse Granitic Sediment on the Distribution and Abundance of Salmonids in the Central Idaho Batholith. M. S. thesis, University of Idaho, Moscow. 85 pp.

McCuddin, Michael Ennis. 1977. Survival of Salmon and Trout Embryos and Fry in Gravel-Sand Mixtures. Masters Thesis, University of Idaho, Department of Natural Resources, Moscow, Idaho. 30 pp.

McNeil, William J., and W. H. Ahnell. 1964. Success of Pink Salmon Spawning Relative to Size of Spawning Bed Materials. U. S. Fish and Wildlife Service, Spec. Sci. Rep. Fish., 469, 15 pp.

Neilson, D. R. 1974. Sediment Transport Through High Mountain Streams of the Idaho Batholith. M.S. thesis, University of Idaho, Moscow. 83 pp.

Newhouse, Henry W. 1979. Current Sediment Conditions in Key Stream Reaches of the Nezperce National Forest Aquatic Evaluation areas. Unpublished. Grangeville, Idaho.

Philipps, Robert W., and H. J. Cambell. 1962. The Embryonic Survival of Coho Salmon and Steelhead Trout as Influenced by some Environmental Conditions in Gravel Beds. Pacific Marine Fishery Committee Annual Report. 14: pp. 60-73.

Platts, William S. 1970. The Effects of Logging and Road Construction on the Aquatic Habitat of the South Fork Salmon River, Idaho. 50th Annual Conference West. Assoc. State Game & Fish Comm. Proc. pp. 182-185.

McCuddin, Michael Ennis. 1977. Survival of Salmon and Trout Embryos and Fry in Gravel-Sand Mixtures. Masters Thesis, University of Idaho, Department of Natural Resources, Moscow, Idaho. 30 pp.

McNeil, William J., and W. H. Ahnell. 1964. Success of Pink Salmon Spawning Relative to Size of Spawning Bed Materials. U. S. Fish and Wildlife Service, Spec. Sci. Rep. Fish., 469, 15 pp.

Neilson, D. R. 1974. Sediment Transport Through High Mountain Streams of the Idaho Batholith. M.S. thesis, University of Idaho, Moscow. 83 pp.

Newhouse, Henry W. 1979. Current Sediment Conditions in Key Stream Reaches of the Nezperce National Forest Aquatic Evaluation areas. Unpublished. Grangeville, Idaho.

Philipps, Robert W., and H. J. Cambell. 1962. The Embryonic Survival of Coho Salmon and Steelhead Trout as Influenced by some Environmental Conditions in Gravel Beds. Pacific Marine Fishery Committee Annual Report. 14: pp. 60-73.

Platts, William S. 1970. The Effects of Logging and Road Construction on the Aquatic Habitat of the South Fork Salmon River, Idaho. 50th Annual Conference West. Assoc. State Game & Fish Comm. Proc. pp. 182-185.

_________________. 1972. Aquatic Environment and Fishery Study. South Fork Salmon River, Idaho. With evaluation of sediment influences. USDA Forest Service, Intermountain Region, Ogden, Utah, 106 pp.

_________________. 1974. Geomorphic and Aquatic Conditions Influencing Salmonids and Stream Classification - with Application to Ecosystem Classification. USDA Forest Service, Surface Environment and Mining Project report, Billings, Montana. 200 pp.

Platts, William S. and Walter F. Megahan. 1975. Time Trends in Riverbed Sediment Composition in Salmon and Steelhead Spawning Areas: South Fork Salmon River, Idaho. Trans. of the 40th North American and National Resources Conference, Wildlife Management Inst., Washington, D.C. pp. 229-239.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Fish. Res. Bd. Can. Bull. 191:328.

Sheppard, J. R. 1960. Investigation of Meyer-Peter, Muller bedload formulas. USDI Hydrology Branch, Denver, Colorado. 22 pp.

Shirazi, M. A. and W. K. Seim. 1979. A Stream System Evaluation -- An Emphasis on Spawning Habitat for Salmonids. EPA-600-13-79-109. 37 pp.

Stuehrenberg, L. C. 1975. The Effects of Granitic Sand on the Distribution and Abundance of Salmonids in Idaho Streams. M.S. thesis, University of Idaho, Moscow. 490 pp.

USDA Forest Service. 1980. Guidelines for Predicting Sediment Yields. USDA Forest Service, Intermountain and Northern Regions, Ogden, Utah, and Missoula, Montana.

APPENDIX A

GLOSSARY

APPENDIX A

GLOSSARY

Anadromous - Fish such as salmon and steelhead trout that spawn and rear their young in fresh water and migrate to the ocean to mature.

Alevin - The stage in the fish life cycle from after the hatching stage until they emerge from the gravel.

Fish Biomass - The weight of fish per unit of area (fish/m^2).

Channel Particle Size Distribution - The distribution of the particles by size (i.e. fine sediments, gravel, rubble, and boulder) that make up the stream channel.

Key Stream Reach - A reach of the stream that is selected because it will show impacts from sediment yield as quickly as any other reach in the stream being analyzed. The reach is also one of the better fish producing reaches on the stream.

Depth Fines - That portion of the channel materials from the surface to a depth of 8 inches that is composed of fine sediments.

Embeddedness - A rating of the degree the larger particle size (gravel, rubble, and boulder) is covered with fine sediments. A zero rating means the particles are free and clear of fine sediments and their

entire perimeter is available for direct contact with the water except for that part touching other particles other than fine sediment. A 100 percent rating would be the complete particle is covered by fine sediment.

Error Band - The range around an estimate at the 95 percent confidence level that the estimate could fluctuate.

Fine Sediment - Those particles in the channel that are all less than 6.3 mm in diameter and of which 20 percent are less than 0.8 mm in particle diameter.

Fishery - The fish and their habitat.

Juvenile - The life stage of a fish from after hatching to the adult stage.

Natural Sediment - Particles derived mainly from streambank erosion of material supplied by creep and other mass erosion processes inherent to the area. Under natural conditions surface erosion is assumed negligible.

Pool Volume - The amount of water a pool contains at different flows.

Percent Fines - That percent of the substrate composition composed of particles less than 6.3 mm in diameter.

Rearing Area - The area of the stream occupied by fish after they leave the gravel.

Resident - Fish who live in the area year around. They do not migrate to the ocean to complete a phase of their life cycle.

Sediment Yield - The average quantity of sediment passing a section in a unit time, i.e., tons/mi^{2}yr. The term may be broken into two components determine total sediment yield.

Smolt - That stage of the fish's life cycle (anadromous species) when they take on certain morphological changes just prior to or during their ascent from the rearing areas to the ocean.

Surface Fines - Those particles on the channel surface less than 6.3 mm in diameter.

Winter Habitat - The area of the stream occupied by fish during the winter. This could be deep pools, rubble-boulder riffles or warmer water areas. In this report, it refers mainly to the rubble-boulder riffle areas where juvenile salmonids go into to survive winter conditions.

APPENDIX B

CHANNEL CLASSIFICATION

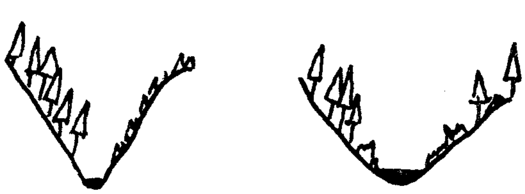
APPENDIX B

CHANNEL CLASSIFICATION

Type A (Not used in this procedure)

These channels are generally contained within narrow valley bottoms with steep slopes or walls on either side. Adjacent landforms are steep with heavy, coarse alluvium or residual soil material. These slopes may be timbered or open, depending upon elevation and aspect. Stream gradient over the reach is normally greater than 6 percent. The degree of channel entrenchment is deep to very deep with annual peak flows contained. The streambed is characterized by bedrock or large boulders with a high degree of amoring and low detachment.

General Cross-section

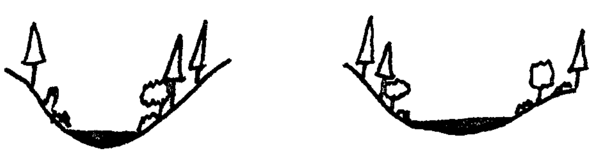


General Plan View

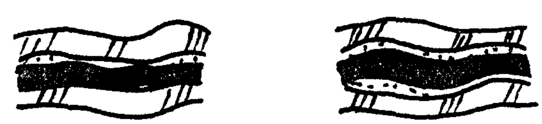
Type B

Type B channels are generally located in narrow to moderately wide valley bottoms with steep to moderately steep slopes on either side. Adjacent landforms have slopes of 0 to 30 percent and can be either concave or convex with coarse alluvium or residual soil material. Slopes may be timbered or open, depending upon elevation and aspect. Stream gradients over the reach may vary between 3 and 6 percent. Channel entrenchment is moderately deep, with annual peak flows generally contained. The streambed is characterized by small to large boulders and gravel, with some sand or silt. Streambed is moderately amored with moderate detachment.

General Cross-section



General Plan View



Type C

Type C channels are generally located in moderately wide to very wide valley bottoms. Valley slopes may vary considerably, depending upon overall terrain. Adjacent landforms are generally low in gradient, containing fine textured residual soils. These land forms may be timbered or open, depending upon elevation and aspect. Stream gradient over the reach is normally less than 4 percent. Channel entrenchment is shallow with frequent overbank discharge. The streambed is characterized by large amounts of gravel, sand, and silt, with lesser amounts of small boulders. Streambed has little or no armoring with easy detachment.

General Cross-section

General Plan View

APPENDIX C

SEDIMENT YIELDS/FISH BIOMASS RELATIONSHIPS

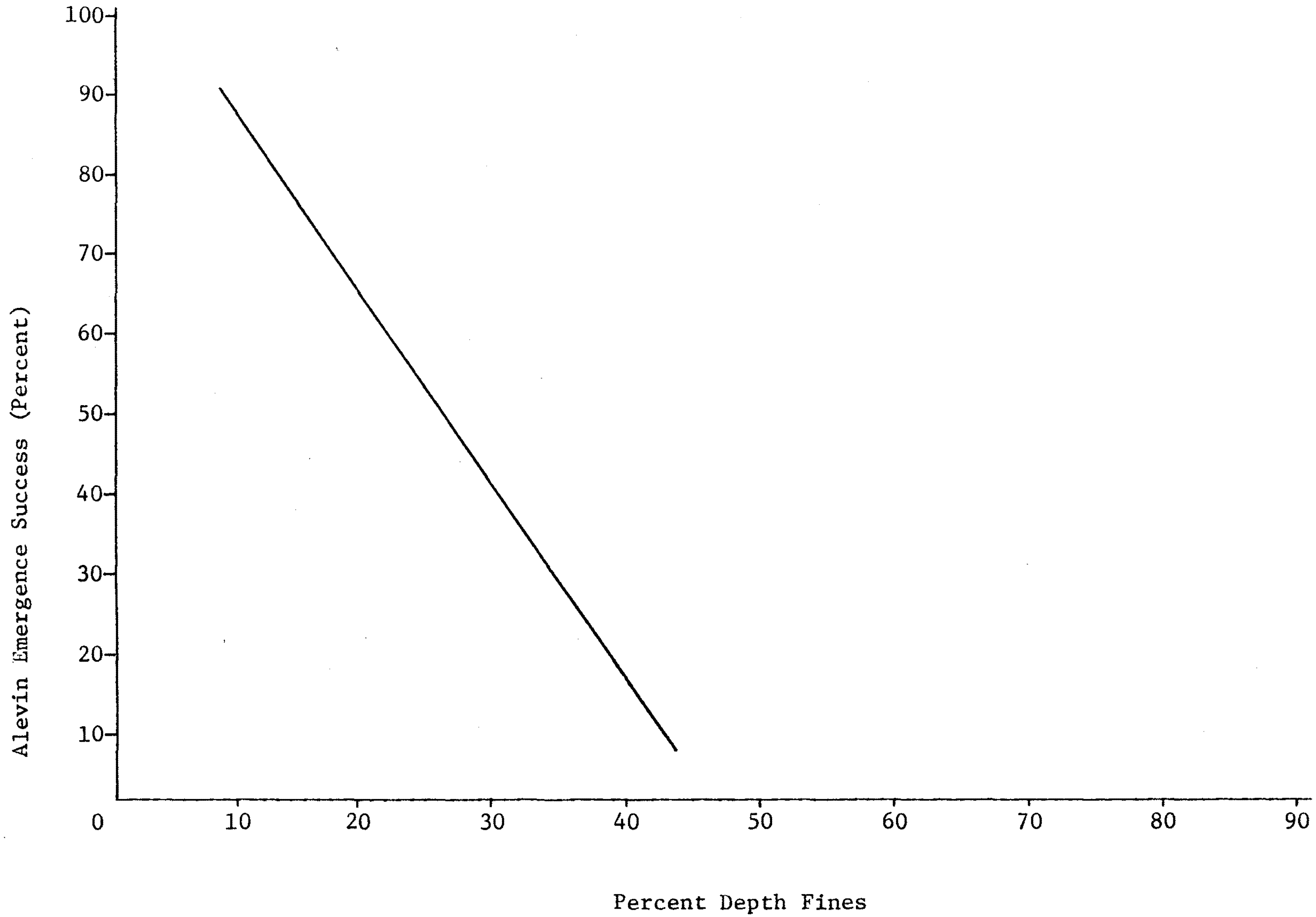


Figure C-1. Steelhead trout, resident trout, and chinook salmon fry emergence success as related to percent fine sediment by depth (McCuddin 1977).

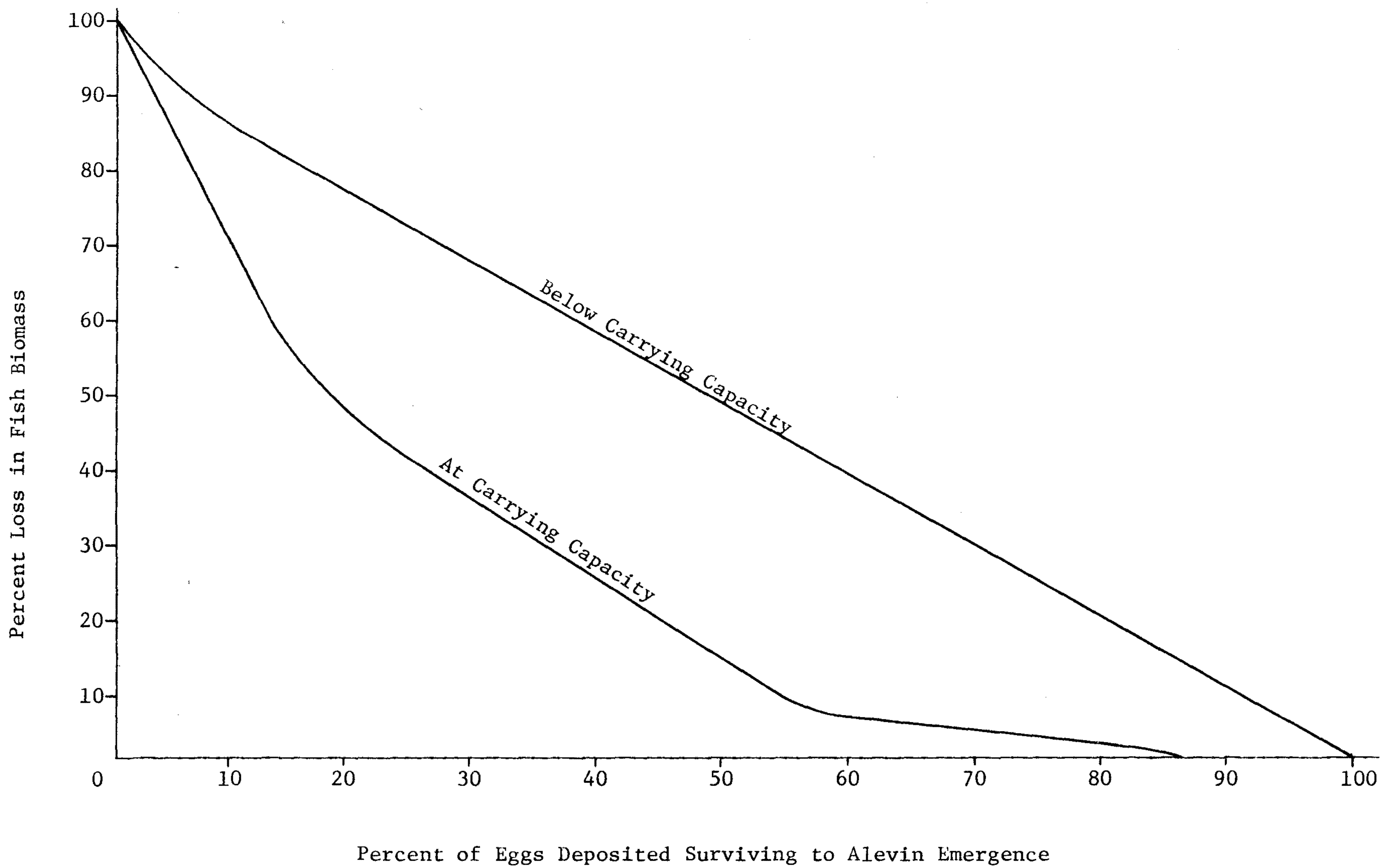


Figure C-2. The relationship between incubation success and percent loss in fish biomass (Bjornn 1969, Cooper 1965, Klampt 1976, Ricker 1975, Philipps and Cambell 1962, and Stuchrenberg 1975).

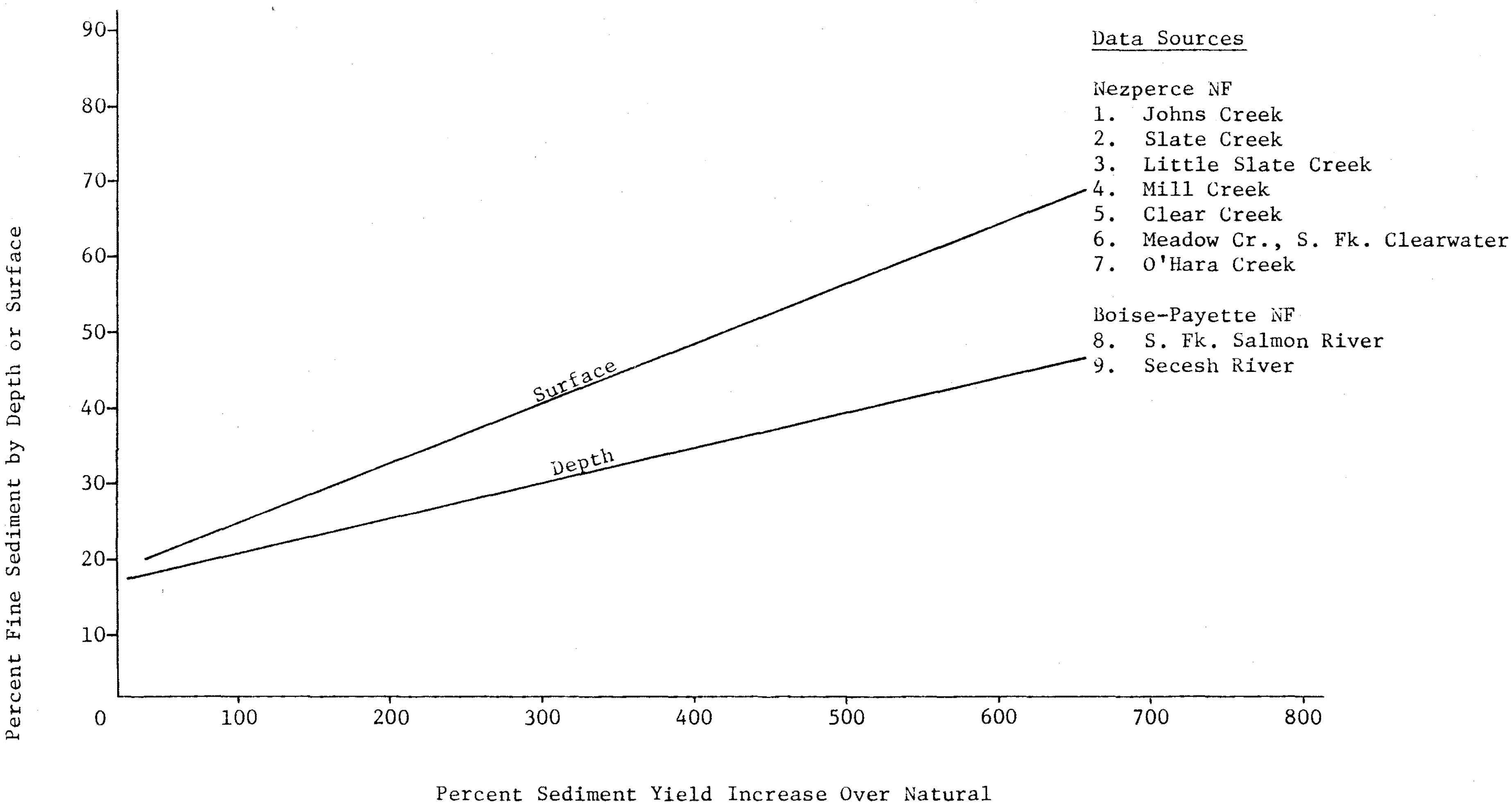


Figure C-3. Resulting percent fine sediment in a key reach by surface and depth measurement as related to percent sediment yield over natural reaching the key reach (Burns 1978, Corley 1979, Newhouse 1979, and Platts 1972).

As the sediment yield over natural increases the cobble embeddedness and percent surface fine sediment in a riffle reach increases.

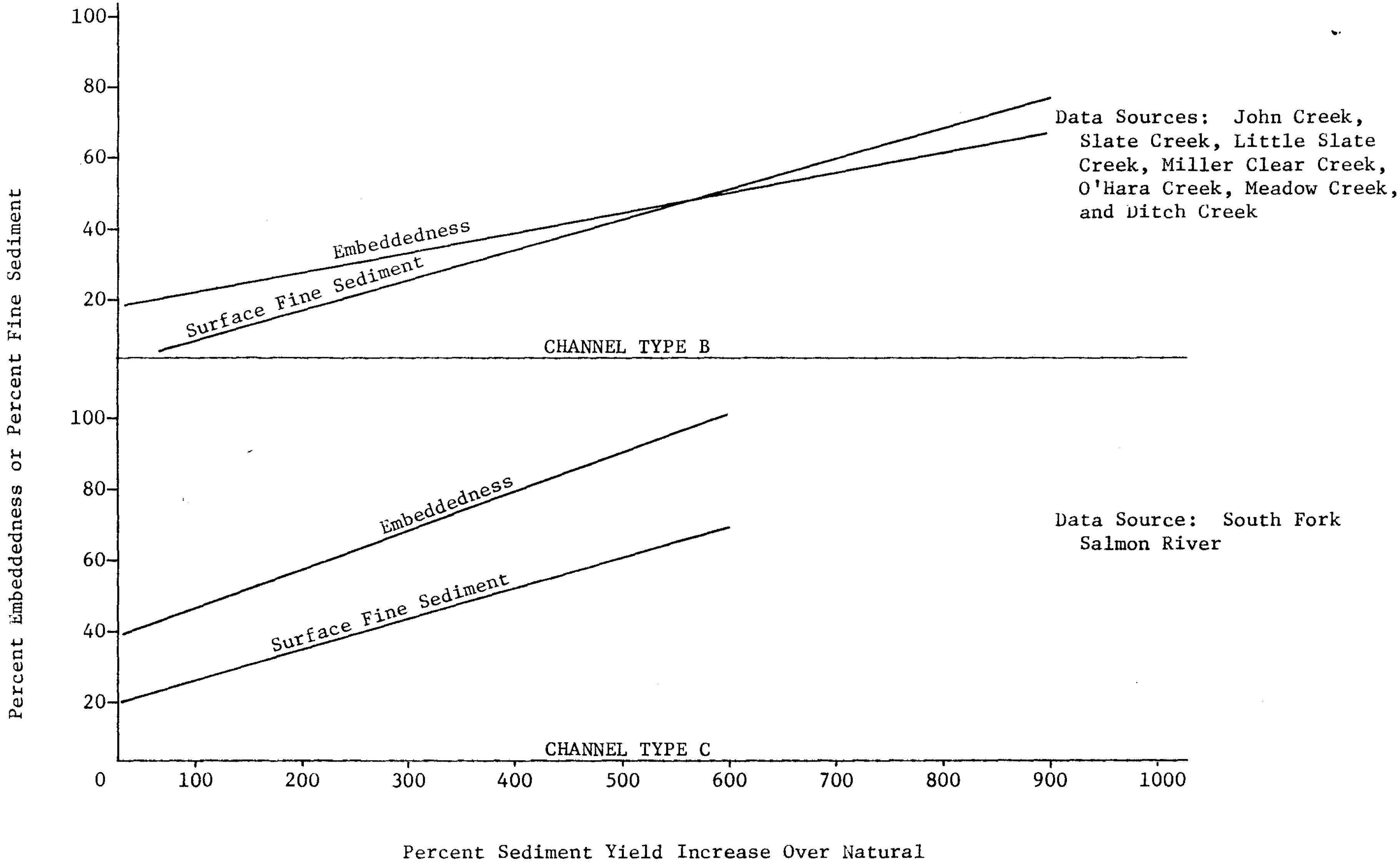


Figure C-4. Embeddedness rating and percent surface fines sediment in a riffle stream reach as a function of the sediment delivered to the channel (Burns 1978, Platts 1972 and 1974).

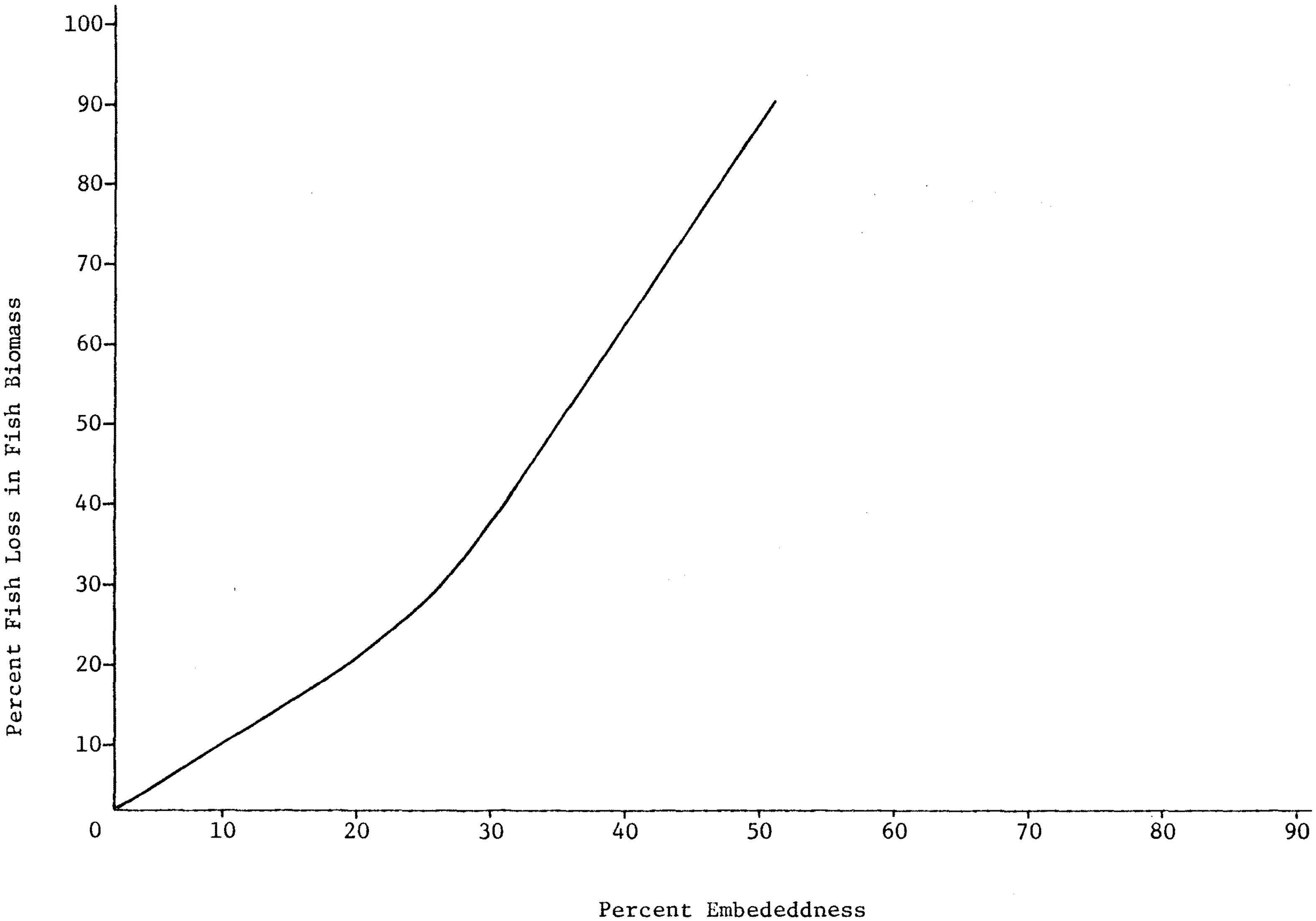


Figure C-5. Percent fish biomass related to embeddedness in winter rearing riffles.
Data Source: Bjornn and Brusuen, 1977

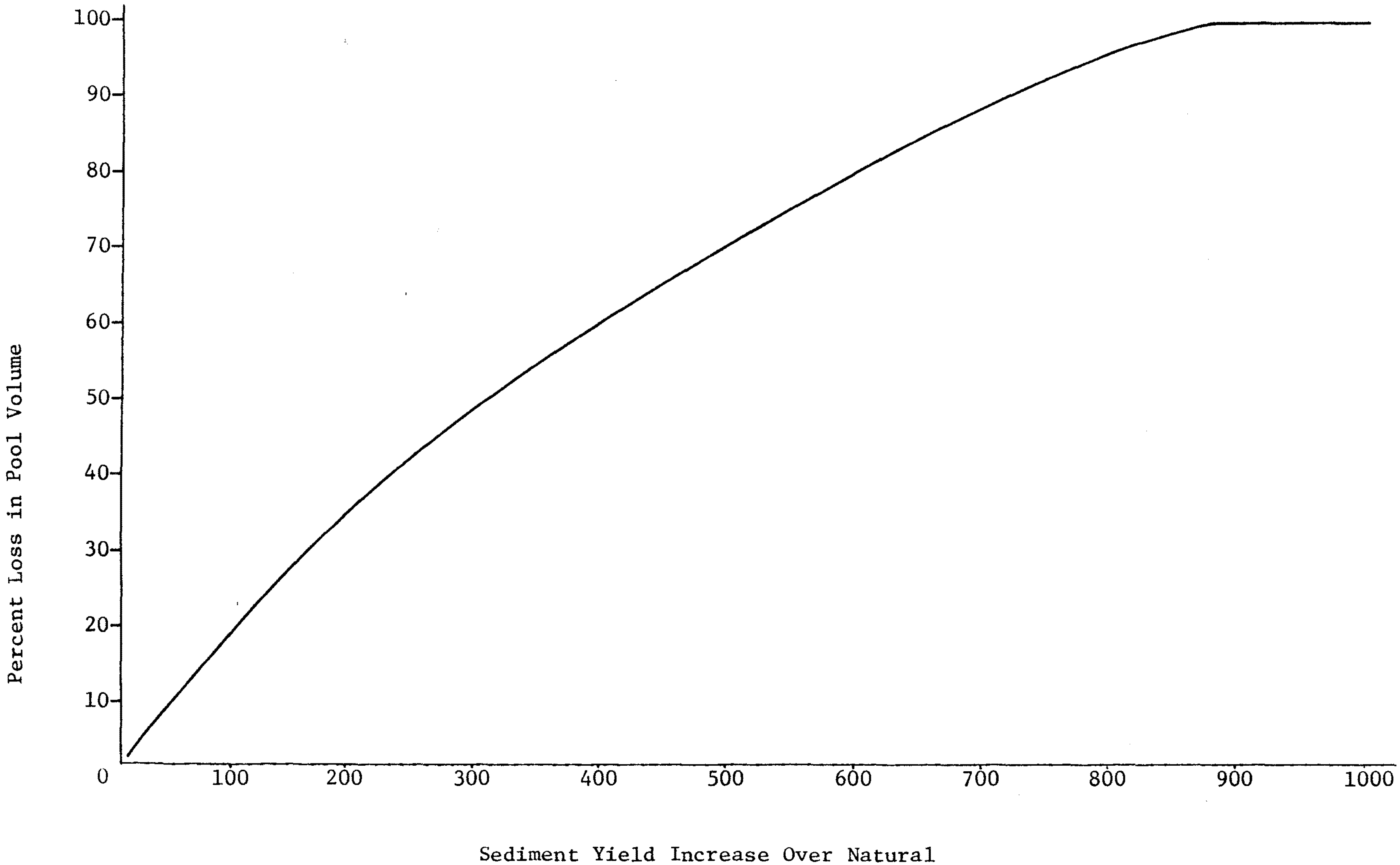


Figure C-6. Relationship between sediment yield and percent loss in pool volume (Platts 1972).

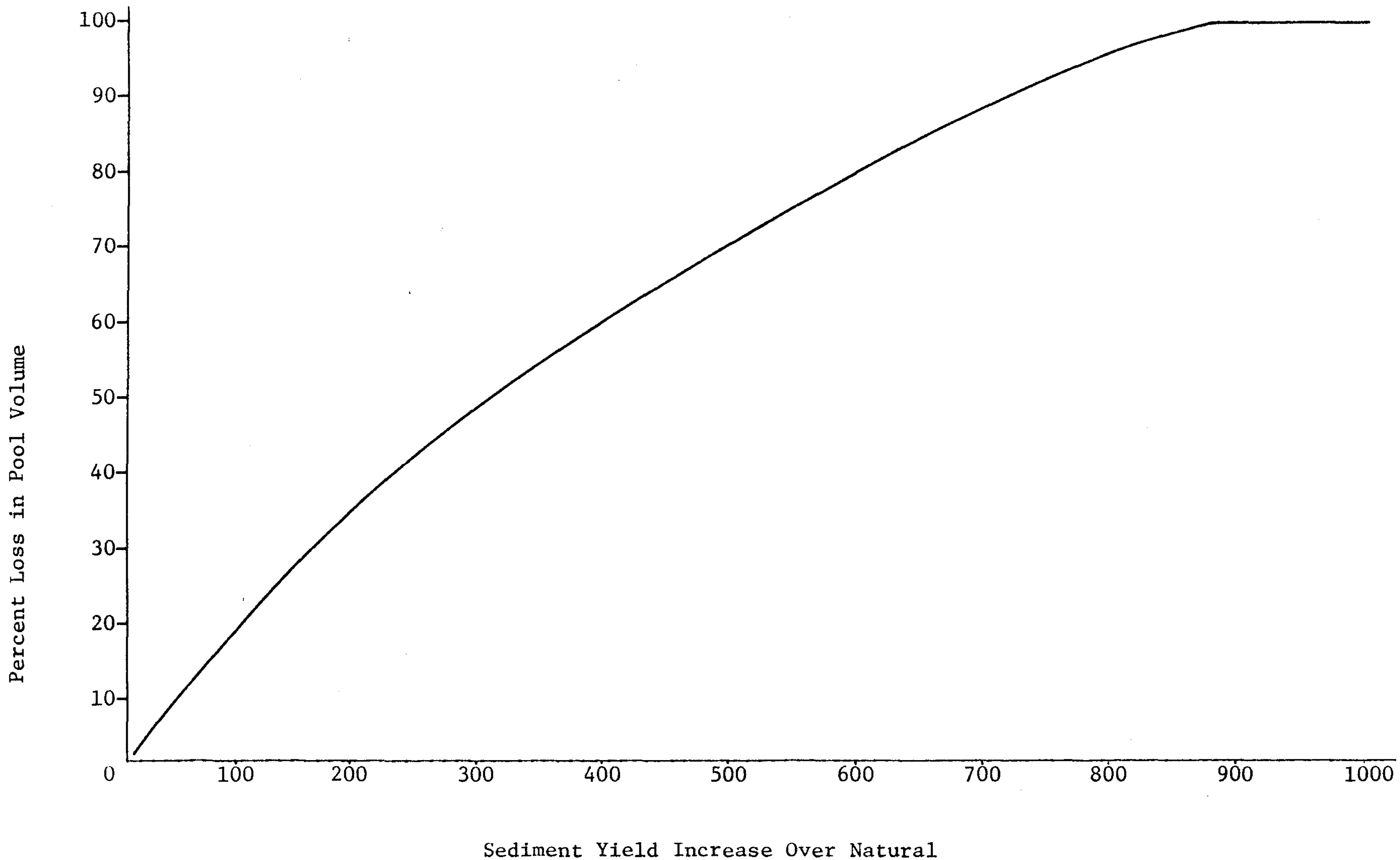


Figure C-6. Relationship between sediment yield and percent loss in pool volume (Platts 1972).

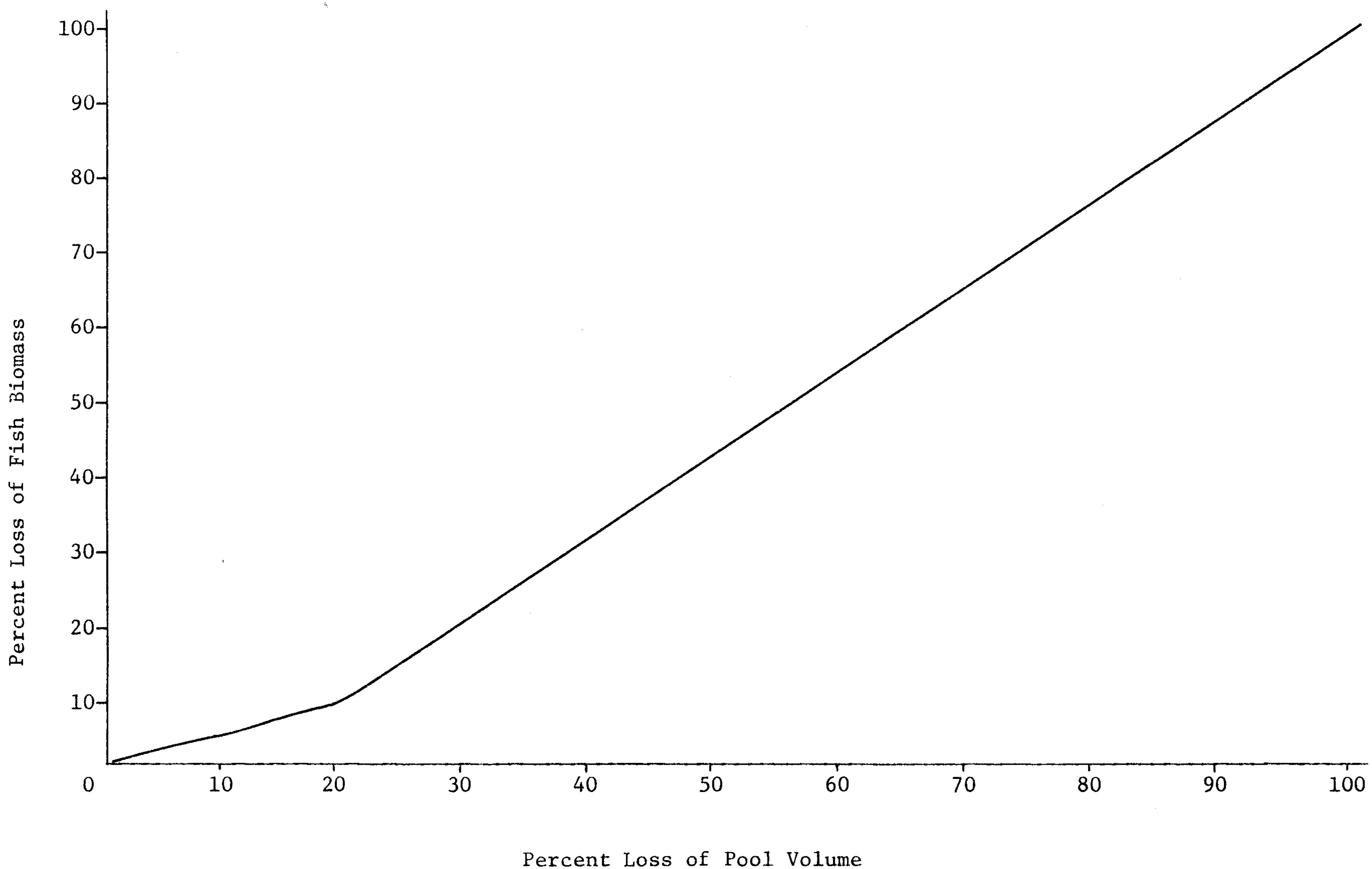


Figure C-7. Relation between pool volume and fish biomass (Klampt 1976).